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A General Equilibrium Analysis  
of Employment Vouchers

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# Search Subsidies vs Hiring Subsidies: A General Equilibrium Analysis of Employment Vouchers

Marco Fugazza\*

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## Abstract

In a two-sided search model, where the matching function is characterized by ex post match-specific heterogeneity and variable search intensity, the relative performance of search and hiring subsidies in terms of both cost effectiveness and aggregate efficiency is assessed. Conditions for cost effectiveness to be obtained are defined for both instruments. A computational exercise shows that search subsidies tend to be more efficient than hiring subsidies, specially in terms of underemployment.

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# 1 Introduction

Unemployment benefits have become a prominent institution in European countries. However, they are accused of creating disincentives to job search and therefore of increasing the length of unemployment spells. Empirical studies<sup>1</sup> have found a positive relation between the degree of persistence of unemployment and with the duration for which unemployment benefits are payable. The perverse effects of unemployment benefits are present also on the demand side of the labor market<sup>2</sup>. Unemployment benefits make firms more reluctant in hiring new employees because of the negative effect they have on equilibrium reservation values, reducing firms return from extra hiring. The abolition of unemployment compensation would certainly remove both the search disincentive and the hiring disincentive effects. However, it may also introduce some other kind of inefficiencies, specially in the presence of imperfections in other markets or of externalities. If agents are risk-averse and financial markets are incomplete, i.e. borrowing is either limited or exogenously precluded, unemployment benefits become an efficient insurance scheme against idiosyncratic risk, as shown in Flemming [7]<sup>3</sup>. Moreover, as shown in Wright [29], unemployment benefits may be socialized via the electoral process, even if insurance technologies are available in the economy. In Marimon and Zilibotti [16], unemployment insurance allows workers to spend more time in looking for the most suitable job. The misallocation of resources to mismatch is subsequently reduced when a skill-biased technological change is introduced.

These two facts lead to unambiguous policy recommendation: search and/or hiring incentives have to be restored within an unemployment insurance scheme, so as to reduce existent inefficiencies without introducing new ones.

In Easley, Kiefer and Posden [6], both the relative and joint perfor-

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<sup>1</sup>See Bean [1].

<sup>2</sup>See, for example, Blanchard and al. [2].

<sup>3</sup>In Hansen and Imrohroglu [8], these efficiency improvements are mitigated when moral hazard is introduced.

mances of unemployment insurance and negative income tax systems are assessed. Wright [29] finds that unemployment benefits should decline with the duration of unemployment. Hopenayn and Nicolini [9] look at the features of an optimal unemployment insurance contract in an environment where the probability to find a new job depends on the search effort made by the agent. In this model the principal (e.g. the government) does not observe workers' search effort. The authors first, find, like Wright [29], that the level of unemployment benefits should be a decreasing sequence. Second, the tax rate after re-employment should increase with the length of the unemployment spell. The latter unemployment insurance and tax schemes are efficient in terms of search incentives but may have mitigated results if adverse selection is taken into account. Pissarides [23] demonstrates how progressive income taxes can be used to offset the search disincentive effects of unemployment insurance. Such taxes have to be coupled with a search subsidy when the search effort is not fixed but perfectly observable. In this taxation framework, high-paying jobs become less attractive exerting downward pressure on the reservation wage. Indeed, progressive income tax lowers the expected return of employment, and thus discourages the unemployed from searching. Ljungqvist and Sargent [13] explore the role of search incentives in explaining the various unemployment experiences of European welfare states. They assess the effects of a progressive income tax scheme on the national product and unemployment rates. Their modelling exhibits a trade-off between a higher search effort and aggregate efficiency. By introducing some kind of government control over the unemployed, they are able to explain how low unemployment can be coupled with generous unemployment policies.

Labor subsidies are instruments able to fit the above policy recommendation. Labor subsidies are thought to be the right stimulus to employment inflow<sup>4</sup>. They are an active employment policy, in the sense that they aim at stimulating employment<sup>5</sup>. A peculiar form of labor

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<sup>4</sup>See CEPR [4], chapters 7,8.

<sup>5</sup>The implementation of Active Labour Market Policies is highly recommended by various organisations. See, for example, OECD [19], [20].



subsidies are the so-called employment vouchers. They differ from other general employment subsidies in the sense that they are paid only to unemployed workers. To all intents and purposes they act as a marginal employment (or, more strictly, hiring) subsidy for an unemployed worker. Thus, persistence in unemployment can be curbed, as it is commonly recognized that the probability of being retained is larger than the probability of being fired. In addition, employment vouchers are thought to be an appropriate way of dealing with market failures that lead to excessive real wages and thereby depress the labor demand. They are an efficient instrument for reducing labor costs regardless of the source of such excessive costs<sup>6</sup>. Employment vouchers are subsidies for hiring unemployed workers, and they can be implemented through a wide variety of policy instruments. It is generally argued that they may be indifferently granted to employers and employees. In practice, they principally correspond to targeted subsidies, that is, only particular groups of unemployed are provided with, and are generally cashed in by the employers. There is little “empirical” evidence about the effects of employment vouchers on search intensity. Woodbury and Spiegelman [28] and Dubin and Rivers [5] have made some experimental estimates of the impact of wage subsidies and of search bonuses<sup>7</sup>. One of their main results is that both of the previous policies have a positive impact, but upon different segments of the labor force. In Orszag and Snower [21], the potential short-run and long-run effect of vouchers on employment are analyzed within a partial equilibrium set up. Deadweight and displacement effects are introduced together with a specific governmental budget constraint such that no net cost is imposed on tax payers. They use a two-state Markovian process to characterize the employment opportunities, and both hiring and firing probabilities are functions of the voucher level. The optimal level of voucher to be ascribed is positively correlated with the level of benefit and negatively linked to the dead weight and displacement costs. This optimal level corresponds to both short-run and

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<sup>6</sup>See Snower [26] for an extended discussion of the purpose.

<sup>7</sup>These large-scale experiments have been undertaken in Illinois, New-Jersey and Washington State.

long-run improvements in the level of employment<sup>8</sup>. However, incentives compatible schemes can not be assessed in this kind of framework.

In this paper employment vouchers take the form either of a search subsidy (interpreted as a search bonus) paid to the unemployed worker once she has found a job, and decreasing with the length of the unemployment spell<sup>9</sup>, or of a hiring subsidy cashed in by the firm once a new worker has been hired. Both instruments affect agents' decisions and consequently equilibrium values. In particular, search subsidies may stimulate at the first place search effort, as found in Dubin and Rivers [5], and hiring subsidies the hiring willingness of firms. It is also clear that more intensive job search is unable to create new jobs on its own while hiring subsidies may. However, in terms of the Beveridge curve, which relates vacancies to unemployment, a larger search effort may shift it in. Indeed, both the shape and the position of the Beveridge curve are influenced by the search behavior of the unemployed. For many European countries a shift-out of the curve has been observed<sup>10</sup>. Therefore, a higher level of job search may help to recover a lower rate of unemployment as much as hiring subsidies may stimulate employment.

The approach is to build an equilibrium search model, with stochastic job matchings and variable search intensity, so as to imitate the employment law of motion and to assess welfare indicators. I first attempt to identify a trade-off between lower unemployment, and cost effectiveness and/or aggregate efficiency, and then to assess the relative performance of the two policy instruments in terms of this trade-off<sup>11</sup>. Conditions for cost effectiveness to be obtained exist for both instruments. Never-

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<sup>8</sup>This is the first attempt to look at the dynamics of targeted labour subsidies. The literature has focused so far largely on comparative statics, as in Snower [27].

<sup>9</sup>This scheme is similar to tax scheme presented in Hopenayn and Nicolini [9]. However, unemployed workers perceive it not as an income threat but rather as an income bonus.

<sup>10</sup>See OECD [20].

<sup>11</sup>As only risk neutral agents are considered, the benefits from risk sharing will not be captured. However, as gains from risk sharing do not contrast with gains from improved search and/or hiring incentives, I will still be able to conclude that an instrument, if it has got satisfactory effects, fits the policy recommendation stated previously.



theless, instruments are expected to lead to contrasting results in terms of aggregate efficiency. In particular hiring subsidies expected to reduce reservation values while search subsidies are expected to increase them. The computational exercise shows that hiring subsidies tend to dampen aggregate efficiency more than search subsidies do, making the above trade-off to large to be socially viable.

The rest of the paper is organized as follows. The next section describes the benchmark economy. Steady state and optimum conditions for the policy augmented economies are shown in section 3. Section 4 presents some sufficient conditions for cost effectiveness to be obtained, as well as the corresponding optimal values of policy instruments. Section 5 considers efficiency and aggregate welfare indicators. Section 6 contains the computational strategy followed to find steady state values. It also presents the calibration of the model and the computational results. The final section concludes.

## 2 The Benchmark Economy

### 2.1 The Labor Market

There are many ex-ante identical workers and many ex-ante identical firms, and each operates as an atomistic competitor. Workers are either unemployed or brought together with a firm by a job-matching technology. Unemployed workers are searching for jobs at a positive cost and firms are recruiting through vacancy creation. Frictions arise in the economy because, ex-post, the productivity of a job-worker pair is a random drawing from a probability distribution  $g(\alpha)$  known by both agents. However, once contact between the firm and the worker is made, the productivity of the match is known with certainty. There is an ex-post match-specific heterogeneity. This is referred to as stochastic job matchings. Workers are assumed to be separated from jobs following a Poisson process with rate denoted  $s$ . Firms decide whether to open or not a vacancy  $v$  while workers choose search intensity  $c$ . There is also a common

choice variable, the reservation productivity  $\alpha_r$  below which neither the firm nor the worker will want to trade. Matching occurs at the aggregate level, at a rate  $(1 - G(\alpha_r)) M(cu, v)$ , where  $u$  is unemployment and  $cu$  can be defined as the "efficiency units" of searching workers. The matching technology  $M(cu, v)$  has the standard properties. It is assumed to be increasing in both its arguments, concave, and homogenous of degree 1. Let us define the  $v:u$  ratio as the labor market tightness and let us denote it by  $\theta$ . The process that changes the state of vacant jobs is Poisson with rate

$$q(\theta, c, \alpha_r) = (1 - G(\alpha_r))m\left(\frac{cu}{v}, 1\right) \quad (1)$$

The representative unemployed workers<sup>12</sup> move into employment according to a Poisson process with rate

$$p(\theta, c, \alpha_r) = (1 - G(\alpha_r))m(c, \theta) \quad (2a)$$

$p$  and  $q$  are related by  $p(\theta, c, \alpha_r) = \theta q(\theta, c, \alpha_r)$ . Both  $p$  and  $q$  are increasing in an exogenous rise in  $c$ , and decreasing in an exogenous rise in  $\alpha_r$ .

At the steady state equilibrium, the flow into unemployment is equal to the flow into employment, that is

$$s(1 - u) = \theta q(\theta, c, \alpha_r)u$$

Thus, assuming that the labor market is large enough so that deviations from the mean can be ignored, the rate of unemployment is given by

$$u = \frac{s}{s + \theta q(\theta, c, \alpha_r)} \quad (3)$$

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<sup>12</sup>The transition probability of worker  $i$  in unit time is given by  $p_i(\theta, c_i, \alpha_{ri}) = (1 - G(\alpha_{ri})) \frac{c_i}{cu} m(cu, v)$ .



$\frac{1}{u}$  can be interpreted as the time that the typical worker will spend unemployed over an infinite working life. Indeed, as  $s$  is the exit rate from employment and  $\theta q(\theta, c, \alpha_r)$  is the rate at which workers transit from unemployment to employment, the representative worker's unemployment history is a Markov chain where  $u$  is the ergodic probability of unemployment.

## 2.2 Firms

We assume that firms are small and each has one job that is either vacant or occupied by a worker. When the job is occupied the firm produces output  $\alpha y$ , where  $y$  is a fixed value as we assume that labor is the only production factor. When it is vacant, the firm is actively engaging at a cost  $\gamma w^e$  where  $w^e$  is the average wage in the economy. Firms return a worker at a rate equal to the transition rate for vacant jobs. Let  $V$  be the present discounted value of expected profit from a vacant job and  $J$  the present discounted value of expected profit from an occupied job. At steady state,  $V$  and  $J$  satisfy

$$rV = -\gamma w^e + q(\theta, c, \alpha_r)(J^e - V) \quad (4)$$

$$rJ = \alpha y - w + s(V - J) \quad (5)$$

Following Pissarides [24] the zero-profit or free entry condition  $V = 0$  is made in order to close the model. The latter condition means that vacancies adjust instantaneously to eliminate pure profits or losses attributable to keeping a job vacant. It implies that

$$J^e = \frac{\gamma w^e}{q(\theta, c, \alpha_r)} \quad (6)$$

There is a reservation productivity  $\alpha_f$  such that all  $\alpha_h \geq \alpha_f$  are accepted. The reservation productivity of the firm is defined by condition  $J = 0$ . Hence, from equation (5)

$$\alpha_f y - w_f = 0 \quad (7)$$

Taking the conditional expectation of (5) and introducing (6) we obtain the condition for jobs

$$\alpha^e y - w^e - (r + s) \frac{\gamma w^e}{q(\theta, c, \alpha_r)} = 0 \quad (8)$$

## 2.3 Workers

We are interested in the behavior of the representative worker. In equilibrium all unemployed workers search with the same search intensity noted  $c$ . It is further assumed that unemployed workers undertake their own job search, supplying their own hours. Time available is normalized to unity. Hence, the leisure time available to the unemployed worker is  $1 - h(c)$  where  $h'(c) > 0$  and  $h''(c) \geq 0$ <sup>13</sup>. The imputed value of leisure time to the worker is set proportional to the after-tax wage rate. Income during unemployment is then given by  $\nu[1 - h(c)](1 - t_b)w^e$ , where  $\nu' > 0$  and  $\nu'' \leq 0$ . In the theoretical derivations that follow, we assume for convenience, and without any loss of generality, that  $h''(c) = 0$  and  $\nu'' = 0$ . Unemployed workers also receive some unemployment benefits  $\rho(1 - t_b)w^e$  of non limited duration<sup>14</sup>. Thus, the valuation placed on unemployment is given by

$$rU = (\nu[1 - h(c)] + \rho)(1 - t_b)w^e + p(\theta, c, \alpha_r)(E^e - U) \quad (9)$$

Taxation is proportional and the tax rate is chosen such that, at equilibrium, tax revenue covers expenditures on unemployment benefits. That is

<sup>13</sup> $c$  will lie on an interval  $[0, c_{\max}]$  such that  $h(c_{\max}) \leq 1$ .

<sup>14</sup>Setting hiring cost, leisure valuation, and unemployment benefits proportional to the expected wage has no strong economic rationale. However, it has no consequences in terms of qualitative results, compared to expected wage independent specifications and brings more clarity to the analysis, specially when cost effectiveness constraint is introduced.

$$\rho(1 - t_b)u = t(1 - u) \quad (10)$$

The net worth of being employed is given by

$$rE = (1 - t_b)w + s(U - E) \quad (11)$$

where again  $s$  is the exogenous separation rate.

$rU$  represents the permanent income of an unemployed worker, that is, the minimum compensation that an unemployed worker requires to accept a job offer. This corresponds to the definition of the reservation wage, the minimum wage that an unemployed worker would accept.

$$w_r = rU \quad (12)$$

From equation (9) and conditional expectations of (11) we obtain that

$$\frac{w_r}{w^e} = \frac{[(r + s)[\nu[1 - h(c)] + \rho] + p(\theta, c\alpha_r)](1 - t_b)}{r + s + p(\theta, c, \alpha_r)} \quad (13)$$

Provided that the condition  $\frac{\partial w^e}{\partial w_r} \frac{w_r}{w^e} < 1$  is satisfied, standard partial comparative statics are verified. Under this assumption an exogenous rise in the right-hand side of equation (13) raises the reservation wage. That is, replacement ratio  $\rho$  raises the reservation wage while search cost reduces it.

The First Order Condition for  $c$  is given by

$$h'(c)\nu'[1 - h(c)] = \frac{(1 - \nu[1 - h(c)] - \rho)p(\theta, c, \alpha_r)}{r + s + p(\theta, c, \alpha_r)} \frac{1}{c} \quad (14)$$

The left hand side represents the net loss of extra search effort, while the right hand side represents the discounted net gain of extra search effort. As usual, the replacement ratio affects negatively search effort. The tax rate does not appear in the above equation as it affects identically both net income from work and the share of labor in the bargain over wage, as shown in equation (15).

## 2.4 Wages

The equilibrium wage is derived from a Nash Bargain between firms and workers when they meet. It maximizes the weighted product of the worker's and firm's net return from the job

$$\max_w (E - U)^\beta (J - V)^{1-\beta}$$

$$s.t \ E + J - U - V = S$$

Where  $S$  stands for the surplus of the match. Search cost and unemployment benefits are proportional to the average wage in the economy at that moment in time. The wage offer a particular unemployed worker may get has no effect on the average net worth of unemployment.

The First Order Condition for  $w$  gives

$$\beta \frac{\partial E}{\partial w} (J - V) + (1 - \beta) \frac{\partial J}{\partial w} (E - U) = 0$$

That is,

$$E - U = \frac{\beta(1 - t_b)}{1 - \beta} (J - V) \quad (15)$$

By imposing the equilibrium condition  $V = 0$ , and by substituting (9) and (11) into the left hand side of expression (15), (4) and (5) into the right hand side, we obtain the equation for the average wage

$$w^e = \frac{\beta \alpha^e y}{[\beta(1 - \theta \gamma) - (1 - \beta)(\nu[1 - h(c)] + \rho - 1)]} \quad (16)$$



## 2.5 Equilibrium

It is now straightforward to define equilibrium conditions. The equilibrium unemployment is defined by equation (3). The reservation productivity is obtained by substituting  $w_r$  and  $w^e$  from equations (13) and (16) into equation (7) and is given by

$$\frac{\alpha_r}{\alpha^e} = \frac{\beta}{1 - \beta} \frac{(\nu[1 - h(c)] + \rho)(1 - t_b)(1 - \beta) + \beta\theta\gamma}{[\beta(1 - \theta\gamma) - (1 - \beta)(\nu[1 - h(c)] + \rho - 1)]} \quad (17)$$

Assumption  $\frac{\partial w^e}{\partial w_r} \frac{w_r}{w^e} < 1$  implies that  $\frac{\partial \alpha^e}{\partial \alpha_r} \frac{\alpha_r}{\alpha^e} < 1$  is verified. Again, a rise in the right-hand side will raise the reservation productivity. Hence, the replacement ratio will raise the reservation productivity implying that in this framework it becomes a shift variable in the relationship between  $v$  and  $u$ .

The tightness condition is obtained by introducing expression (16) into the jobs condition (8)

$$(1 - \beta)(1 - \nu[1 - h(c)] - \rho) - \beta\theta\gamma - \frac{(r + s)}{q(\theta, c, \alpha_r)}\beta\gamma = 0 \quad (18)$$

Using the outcome of the Nash Bargaining, the condition for optimal search effort is

$$ch'(c)\nu'[1 - h(c)] = \frac{\beta}{1 - \beta}\gamma\theta \quad (19)$$

The system is recursive. Equations (17), (18) and (19) give the steady state values for  $\alpha_r$ ,  $c$ ,  $\theta$ . With knowledge of these variables equation (3) gives the equilibrium rate of unemployment. Moreover, by differentiating equations (18) and (19) with respect to the reservation productivity we find that the effects  $\alpha_r$  has on them cancel each other out, so equations (18) and (19) are independent of  $\alpha_r$ . Hence, they can be

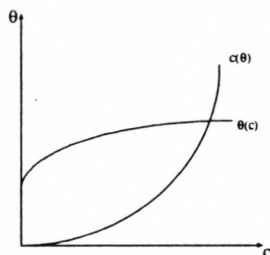


Figure 1: Equilibrium search intensity and tightness

solved for  $\theta$  and  $c$ . As represented in 1, uniqueness of equilibrium is ensured by constant returns in the job-matching technology together with "input-augmenting" search intensity.

In a  $(u, v)$  space, equation (3) gives the so called Beveridge curve or  $UV$  curve. As it is usually assumed in the theoretical literature, we assume here that the effects operating through the probability to make a contact, namely the search effect and the vacancy effect dominate the effect operating through the rejection of a job offer, namely the reservation-wage effect. Because of this assumption, which has found strong empirical support<sup>15</sup>, and because of the assumed properties of the matching function the  $UV$  curve is downward sloping and convex to the origin. The "production side" of the economy is represented by the so-called  $VS$  curve, hinging on equation (29). By setting  $\theta = \frac{v}{u}$ , and by introducing equation (3), we obtain a relation between  $v$  and  $u$  that is upward sloping if

$$u < \frac{s}{2s + r}$$

<sup>15</sup>See for example Pissarides[17] and Mortensen [22].

which is certain to be satisfied for values of  $\tau$  small enough.

### 3 Policy Instruments

We consider two policy instruments apart from unemployment benefits and wage taxes paid by the worker in order to finance the policy, namely search subsidies and employment subsidies. Search subsidies are cashed in by the worker once she has accepted an offer. Hiring subsidies are paid to the firm for each new worker it hires. These two instruments would have equivalent qualitative effects within a framework where search intensity is hold constant and matching is not stochastic. However, when the theoretical framework is enriched by assuming that search intensity can vary and matching is assumed to be stochastic, then, as will be shown below, it makes a difference to whom the employment subsidy is paid.

#### 3.1 Search Subsidies

Actual search subsidy is defined by

$$p(\theta, c, \alpha_r) \lambda (1 - t_s) w^e \quad (20)$$

Actual search subsidy is then increasing in search effort as the transition rate is increasing in search effort.

Search effort is not perfectly observable. Hence, from a practical point of view, search bonuses are conceivable only if they take the form of a lump sum transfer. However, search effort affects directly the length of unemployment spell, which is perfectly observable by governmental authorities. Indeed, in all the European countries, unemployed workers have to register at an unemployment agency in order to draw unemployment compensation. Thus, in the above economy, the longer they stayed unemployed the smaller the voucher they receive. If unemployment compensations are provided only for a finite period of time, a policy scheme equivalent to the above search subsidy scheme would be to allow

the unemployed worker who finds a job before the expiration date of the compensation payment, to cash in, as a lump sum bonus, the amount of unemployment compensation she would have been paid if she had stayed unemployed for the all duration of benefits.

The permanent income expression becomes

$$rU = (\nu [1 - h(c)] + \rho)(1 - t_s)w^e + p(\theta, c, \alpha_r)\lambda (1 - t_s)w^e + p(\theta, c, \alpha_r)(E^e - U) \quad (21)$$

and the reservation wage is now

$$\frac{w_r}{w^e} = \frac{[(r + s)[\nu [1 - h(c)] + \rho] + p(\theta, c, \alpha_r)(1 + \lambda)](1 - t_s)}{r + s + p(\theta, c, \alpha_r)} \quad (22)$$

For  $\frac{\partial w^e}{\partial w_r} \frac{w_r}{w^e} < 1$ , search subsidy increases the reservation wage.

The condition for optimal search is now given by

$$h'(c)\nu'[1 - h(c)] - \frac{p(\theta, c, \alpha_r)}{c}\lambda = \frac{[1 - \nu[1 - h(c)] - \rho - p(\theta, c, \alpha_r)\lambda]p(\theta, c, \alpha_r)}{r + s + p(\theta, c, \alpha_r)} \quad (23)$$

By comparing equation (14) with equation (23), the introduction of search subsidies leads to a higher level of search intensity, holding other variables constant.

### 3.2 Hiring Subsidies

Subsidies are paid to the firm for each new worker it hires. Actual hiring subsidy can be expressed as

$$q(\theta, c, \alpha_r)ew^e \quad (24)$$

The firm's net worth from a job is then



$$rV = -(\gamma - q(\theta, c, \alpha_r)e)w^e + q(\theta, c, \alpha_r)(J^e - V) \quad (25)$$

The condition for jobs is now

$$\alpha^e y - w^e - (r + s) \frac{(\gamma - q(\theta, c, \alpha_r)e)w^e}{q(\theta, c, \alpha_r)} = 0 \quad (26)$$

Hiring subsidies are different from wage subsidies in the sense that they are a "one-shot" paiement and affect at the first place the return from filing a vacancy rather than the return from a job match. As we will see in the next subsection, hiring subsidies will affect positively tightness in a partial equilibrium analysis.

### 3.3 Equilibrium with Policy

The average wage resulting from Nash Bargain is given by

$$w^e = \frac{\beta \alpha^e y}{[\beta(1 - (\theta\gamma - p(\theta, c, \alpha_r)e)) - (1 - \beta)(\nu[1 - h(c)] + \rho + p(\theta, c, \alpha_r)\lambda - 1)]} \quad (27)$$

The equilibrium condition for unemployment has the same expression than in the previous section. Conditions for reservation productivity, tightness and, search intensity are now given by<sup>16</sup>

$$\frac{\alpha_r}{\alpha^e} = \frac{\beta}{1 - \beta} \frac{[\nu[1 - h(c)] + \rho + p\lambda(c)](1 - t_{s,h})(1 - \beta) + \beta(\theta\gamma - pe)}{[\beta(1 - (\theta\gamma - pe)) - (1 - \beta)(\nu[1 - h(c)] + \rho + p\lambda - 1)]} \quad (28)$$

$$(1 - \beta)[1 - \nu[1 - h(c)] - \rho - p\lambda] - \beta(\theta\gamma - pe) - \frac{(r + s)}{p}\beta(\theta\gamma - pe) = 0 \quad (29)$$

<sup>16</sup>The system of equations presented below contains both of the policy instruments. However, in what follows, I assume that they are introduced separately.

$$ch'(c)\nu'[1 - h(c)] - p(\theta, c, \alpha_r)\lambda = \frac{\beta}{1 - \beta}(\theta\gamma - p(\theta, c, \alpha_r)c) \quad (30)$$

Again, the system represented by equations (28), (29) and (30) is recursive, and again (29) and (30) can be solved uniquely for  $\theta$  and  $c$ . Partial equilibrium comparative statics are summarized in table 1.

Table 1: Partial Equilibrium Comparative Statics

	$c$	$\theta$	$\alpha_r$	$w^e$
$s$	+	+	+	+
$e$	-	+	-	-

If we now turn to general equilibrium considerations, search subsidy stimulates search at the first place. However, as it compensates for the search cost of the unemployed worker, it is going to make her more selective in terms of job acceptance. Search subsidy might then raise worker's reservation productivity. These two elements have a contrasting effect on the transition rate from unemployment to employment. In terms of trade externality, more search will be interpreted as a positive one by firms. Their willingness to open up new vacancies is bigger. Nevertheless, firms might be reluctant in doing so if the negative effect on the worker reservation productivity is too important.

As mentioned previously, hiring subsidy affects tightness condition at the first place by reducing the cost of opening up a vacancy. This will also stimulate search as tightness and search are positively linked because of the positive externality that a rise in tightness represents to searchers. Nevertheless, hiring subsidy tends to lower the firms' reservation productivity and subsequently, as shown by equations (28) and (27), to reduce both the equilibrium reservation productivity and equilibrium wage. The latter effect discourages workers from searching more as the return from extra search effort is smaller. It is true that a lower wage also reduces the search cost, but it will be reduced by less than the

return from extra search is reduced. As it is clear from equation (30), we might end up at equilibrium with a higher tightness level, but with a lower search intensity.

In terms of 1 search subsidies make both the  $c(\theta)$  and the  $\theta(c)$  curves flatter and shift down, while hiring subsidies make them steeper and shift up. Hence some further conditions are needed in order to define precisely changes in search and tightness equilibrium values. This is the scope of subsection 4.2.

In a  $(u, v)$  space, a possible outcome of the introduction of one of the two policy instruments here considered is shown in figure one. The  $UV$  curve shifts in while the  $VS$  curve shifts up. Both tightness and vacancy rate raise while unemployment is reduced.

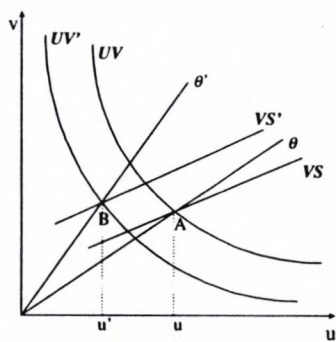


Figure 2: The effects of policy instruments

## 4 Cost Effectiveness

### 4.1 The Budget Constraint

The definition of conditions for cost effectiveness to be obtained is necessary to assess the relevance of the two policy instruments presented previously. The budget constraints for search subsidies and hiring subsidies are respectively

$$(\rho + p_s(\theta, c, \alpha_r)\lambda)(1 - t_s)u_s = t_s(1 - u_s) \quad (31)$$

$$(\rho(1 - t_h) + p_h(\theta, c, \alpha_r)e)u_h = t_h(1 - u_h) \quad (32)$$

The subscripts introduced in the above equations refer to the particular equilibrium values obtained in the two different policy schemes. Subscript  $s$  holds for the search subsidy scheme, and subscript  $h$  for the hiring subsidy scheme. The absence of equilibrium wage  $w$  in the above equations is due to the assumption that no exogenous public expenditures have to be financed. It is obvious that in the presence of exogenous public expenditures the wage rate would play an important role in terms of cost effectiveness.

It is straightforward to isolate  $t_i$ ,  $i = s, h$ , and then to compare its expression with the expression of the equilibrium tax  $t_b$  rate found for the benchmark economy. We obtain that

$$t_b \geq t_s \text{ if} \quad p_s \geq \frac{\rho}{\rho - p_b\lambda} \quad (33)$$

and  $t_b \geq t_h$  if

$$p_h \geq \frac{\rho}{\rho - (p_b + \rho s)e} \quad (34)$$

If we look at the relation between the transition rate and the policy instrument, obtained by strictly equating the left hand side with the right hand side of the above equations it is straightforward to verify that



$\frac{\partial p_s}{\partial \lambda} > 0$  and  $\frac{\partial^2 p_s}{\partial \lambda^2} > 0$  for  $\lambda$  lying on the interval  $\left[0, \frac{p}{p_b}\right]$  and that  $\frac{\partial p_h}{\partial c} > 0$  and  $\frac{\partial^2 p_h}{\partial c^2} > 0$  for  $c$  lying on the interval  $\left[0, \frac{p}{(p_b + p_s)}\right]$ <sup>17</sup>.

**Proposition 1 :** *If some conditions exist such that at equilibrium the transition rate is positively affected by the introduction of a policy instrument, then cost effectiveness is obtained for some positive values of the policy instrument.*

## 4.2 The Transition Rate

In general, the effect of any parameter  $z$  on the worker's transition rate is given by

$$\frac{\partial q(\theta, \alpha_r, c)}{\partial z} = \left( \frac{1 - \eta(\theta, \alpha_r, c)}{\theta} \frac{\partial \theta}{\partial z} + \eta(\theta, \alpha_r, c) \frac{1}{c} \frac{\partial c}{\partial z} - \frac{g(\alpha_r)}{1 - G(\alpha_r)} \frac{\partial \alpha_r}{\partial z} \right) q\theta \quad (35)$$

The three effects contained in the above expression are respectively the vacancy effect, the search effect and the reservation-wage effect. As mentioned previously the first two operate through the probability to make a contact while the last one operates through the rejection of a job offer. By assuming that contact elements dominate the rejection element of the transition rate, and if conditions under which both  $\frac{\partial \theta}{\partial z}$  and  $\frac{\partial c}{\partial z}$  have the same positive sign can be determined, it is then possible to state cost effectiveness for a policy instrument scheme.

From previous analysis it is possible to concentrate on equations (29) or equivalently equation (23) and (30) to solve uniquely for  $\theta$  and  $c$ . Using the implicit function theorem,  $\frac{\partial \theta}{\partial \lambda} > 0$  is verified if

$$h'(c)v'(1 - h(c)) \left[ \frac{p(1 - \beta)\theta + [(1 - \eta(\theta, \alpha_r, c))(r + s) - p]\gamma}{p(1 - \beta)\theta + [(1 - \beta)(r + s) - p]\gamma} \right] > \frac{\partial p}{\partial c} \lambda \quad (36)$$

<sup>17</sup>In what follows, we will only consider policy instruments lying on the respective intervals presented here above. Out of these intervals discontinuity matters would have to be taken into account without adding much to our analysis.

The term into brackets in the LHS of the above expression has to be positive. This is likely to happen for value of  $\beta$  and  $\gamma$  not too large. Condition (36) may be interpreted in the following way. As long as the additional cost of extra search that an unemployed worker faces, which means a lower wage claim, is higher than the additional wage cost that a firm would face if  $\theta$  increases, search subsidy raises equilibrium tightness and equilibrium search<sup>18</sup>

If Hosios' efficiency condition<sup>19</sup> is verified the latter term is equal to 1 and condition (36) reduces to

$$h'(c)v'(1-h(c)) > \frac{\partial p(\theta, c, \alpha_r)}{\partial c} \lambda \quad (38)$$

This is the condition for the LHS of equation (30) to increase when search subsidy is introduced.

**Proposition 2 :** *If condition (36) is verified then search subsidy will have a positive impact on both search and tightness at equilibrium. By assuming that, referring to the transition probability, contact elements dominate the rejection element, search subsidy will increase the transition rate from unemployment to employment.*

Similarly,  $\frac{\partial c}{\partial e} > 0$  is verified if

$$(\tau + s)\gamma \left[ \frac{\beta}{(1-\beta)} + \frac{ch'(c)v'(1-h(c))}{pe} \eta \right] > \frac{\partial p}{\partial \theta} \left[ pe + \frac{\beta}{(1-\beta)} ch'(c)v'(1-h(c)) \right] \quad (39)$$

<sup>18</sup>See appendix 1 for details.

<sup>19</sup>When variable search intensity and stochastic job matchings are introduced separately, the standard Hosios' condition for efficiency holds, namely

$$\beta = \eta(\theta, c, \alpha_r) \quad (37)$$

When taken together, as shown in Pissarides [24] chapter 7, the efficiency condition remains the same as it can be derived independently for search intensity and reservation productivity.

The interpretation of condition (39) is similar to the interpretation of condition (36) in the sense that as long as the return from higher tightness is higher than the cost in terms of equilibrium wage, search will respond positively to hiring subsidy and subsequently equilibrium tightness<sup>20</sup>.

**Proposition 3 :** *If condition (39) is verified then hiring subsidy will have a positive impact on both search and tightness at equilibrium. By assuming that, referring to the transition probability, contact elements dominate the rejection element, hiring subsidy will increase the transition rate from unemployment to employment.*

### 4.3 Optimal Values

In terms of cost effectiveness, the major effect for search subsidy will be observed when, in a  $(p, \lambda)$ space, the slope of the curve characterizing equation (33) is equal to (35). For hiring subsidy a similar condition exists in the  $(p, e)$  space.

If condition (36), respectively condition (39), is satisfied, in addition to the assumption made previously, namely the dominance of the rejection element by the contact elements of the transition rate, and to the constant returns of scale assumption, a concave relationship corresponding to (35), starting from the point characterizing the benchmark steady state, will be obtained in a  $(p, z)$ space,  $z = \lambda, e$ . This guarantees that the optimal level of  $\lambda$ , in terms of cost effectiveness, will be lying on the interval  $\left[0, \frac{\rho}{p_b}\right]$ , respectively that the optimal level of  $e$  will be lying on the interval  $\left[0, \frac{\rho}{(p_b + \rho s)}\right]$ .

The optimal level of search subsidy and hiring subsidy are given respectively by

$$\lambda^* = \frac{\rho \left( C^{1/2} - p^{1/2}(\theta, c, \alpha_r) \right)}{p(\theta, c, \alpha_r)} \quad (40)$$

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<sup>20</sup>See appendix 1 for details.

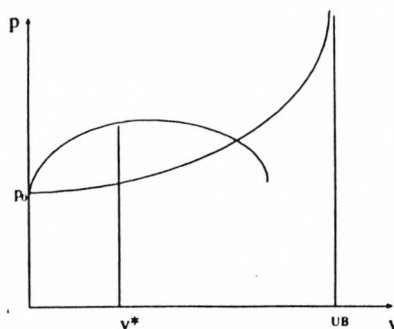


Figure 3: Cost effectiveness and Optimal values

and

$$e^* = \frac{\rho \left( C^{1/2} - \left( \frac{p(\theta, c, \alpha_r) + s\rho}{\rho} \right)^{1/2} \right)}{C^{1/2} (p(\theta, c, \alpha_r) + s\rho)} \quad (41)$$

where  $C = \frac{1-\eta(\theta, \alpha_r, c)}{\theta} \frac{\partial \theta}{\partial z} + \eta(\theta, \alpha_r, c) \frac{1}{c} \frac{\partial c}{\partial z} - \frac{g(\alpha_r)}{1-G(\alpha_r)} \frac{\partial \alpha_r}{\partial z}$ .

If what stated previously is verified, we need no additional conditions for these optimal values to be positive.

**Proposition 4 :** *If condition (36), respectively condition (39), is satisfied, it exists some optimal positive value of search subsidy, respectively hiring subsidy, in terms of cost effectiveness. These values are given respectively by expressions (40) and (41) and are lying on  $\left[0, \frac{\rho}{p_b}\right]$ , respectively  $\left[0, \frac{\rho}{(p_b + \rho s)}\right]$ .*

This is shown in 3, where  $v^*$  refers to the optimal value of the policy instrument.



The optimal value corresponds to the level of policy instrument that corresponds to the higher value of  $p$  that can be obtained controlling for cost effectiveness. It does not unnecessarily correspond to the lowest tax rate.

## 5 Efficiency Analysis

### 5.1 Productivity Distribution and Aggregate Efficiency

Productivity distribution is given by

$$D_t = \frac{p(\theta, c, \alpha_r) [G(\alpha_r) - G(\min(\alpha_r, \alpha))]}{p(\theta, c, \alpha_r) [1 - G(\alpha_r)]} \quad (42)$$

The above expression computes the number of new matches with productivity less than or equal to  $\alpha$  at any point in time. It is straightforward to check that  $D_t$  integrates to one.

Using the fact that  $\alpha$  is a non negative random variable, the average or expected productivity, conditional on job acceptance at a point in time is given by<sup>21</sup>

$$\alpha^e = \int_{\alpha_r}^{\alpha_{\max}} [1 - D_t(\alpha)] d\alpha \quad (43)$$

Because labor is assumed to be the only factor of production in the economy, the Gross National Output corresponds to the average output

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<sup>21</sup>A more straightforward but strictly equivalent definition of the expected productivity conditional on job acceptance is given by

$$\alpha^e = \frac{\int_{\alpha_r}^{\alpha_{\max}} [1 - G(\alpha)] d\alpha}{[1 - G(\alpha_r)]}$$

times the employment level. GNP is adjusted for the disutility of unemployed workers' search for jobs and weighted by the tax rate in order to evaluate fully cost effectiveness. Hence, at equilibrium, it is given by

$$GNP_{adj} = \frac{\alpha^e y(1-u)}{t} - uh(c)(1-t)w \quad (44)$$

This measure of GNP allow an absolute assessment of the relative performance of the policy instruments considered in the previous sections.

## 6 Computational Exercise

### 6.1 Computational Strategy

In order to get a tractable closed form solution for optimal  $c$  and  $\alpha$ , and for equilibrium  $\theta$  and  $u$ , some parameterization can be introduced. In addition, this would help us in providing "quantitative" results. In our calibration exercise, the parameters of the model are  $\tau, \rho, t, e$ , the distribution  $g(\cdot)$  and the functions  $m(\cdot)$  and  $\lambda(\cdot)$ .

The solution algorithm is obtained through the following steps<sup>22</sup>:

1. Solve system of equations (3), (17), (18) and (19) for stationary values of  $\alpha, c, \theta$  and  $u$ .

2. Solve for the stationary productivity distribution for the stationary values obtained in 1.

3. Iterate on steps 1 and 2 in order to reach a balanced government budget given respectively by equations (31) and (32).

$u, v$  and  $w$  are respectively the equilibrium unemployment rate, the equilibrium vacancy rate and the equilibrium wage. A guess for the equilibrium tax rate  $t$  is made, and then step one is followed. If the government is found to be running a surplus (deficit) as an outcome of step 1, the tax rate is lowered (increased), and steps 1 and 2 are repeated until a balanced budget is achieved

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<sup>22</sup>It follows Imrohoroglu [10].

## 6.2 Calibration

In this section I present the outcome of numerical resolution of the model with calibrated parameters. This exercise only aims at quantifying the various trade offs presented in the previous sections. The parameters are chosen such that "plausible" results are obtained in the benchmark economy. A time period of unit length is interpreted to be one quarter. The interest rate is set equal to 0.015, implying an annual interest rate of 6%. The separation rate is fixed at  $s = 0.04$ , corresponding to an average duration of a job of slightly more than six years. This relative high figure becomes realistic once we take into account that quits and job-to-job movements are not considered in the economy. The replacement ratio is set equal to 0.4. As I assume they are provided for an infinite period of time unemployment benefits have to be given a broad definition that may also include any kind of welfare transfers. This explains the relatively low replacement ratio taken for computations. The matching technology is Cobb-Douglas,  $M = k(cu)^a v^{1-a}$ , and  $a$  is fixed at 0.6<sup>23</sup>, and  $k = 0.67$ . I assumed that the imputed value of leisure time was proportional to the wage rate. In the computations I assume that the imputed income is linear in leisure time with coefficient equal to 0.8. The search cost function is increasing and convex in the search level, that is  $h(c) = (b.c)^\varepsilon$ , where  $b$  is set equal to 0.1 and  $\varepsilon$  is set equal to 1.3. The equilibrium value of  $c$  will then lie on the interval  $[0, 10]$ . The hiring cost parameter  $\gamma$  is fixed at 0.3. The productivity distribution  $g(\cdot)$  is exponential with mean equal to 1. The maximum value that  $\alpha$  can take is 8. It is easy to check that it corresponds to a value for which  $G(\alpha)$  is only slightly different from 1. The exponential function is log-concave. Log-concavity, as shown in Burdett[3] implies that the hazard rate rises with an increase in job availability. This guarantees that both search and hiring subsidies will increase transition rate  $p$  and lower the expected duration of unemployment. In terms of equation (35), the right hand side has positive sign. Finally,  $\beta$  is set equal to 0.6 in order to satisfy condition (20). This is done in order to avoid any bias that inefficiency,

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<sup>23</sup>This value has been chosen according to Kiefer[11] and Pissarides[22] estimates.



in terms of trade externalities, could exacerbate once policy instruments are considered.

### 6.3 Results

Two general observations can be formulated. The first one is that cost effectiveness and higher aggregate efficiency, as expected, are obtained for some values of both search and hiring subsidies. The second one is that both policy instruments can have a strong positive effect on the level of unemployment<sup>24</sup>. However, this occurs at a high cost, in particular under the hiring subsidy scheme, in terms of both cost effectiveness and aggregate efficiency.

A more detailed analysis of table 2 tells us that search subsidies tend to stimulate search, to raise tightness and to lower the equilibrium reservation productivity while hiring subsidies tend to raise tightness and to lower both search and reservation productivity ( see figure 1). Lower reservation productivity levels observed under the search subsidy scheme reveal that, in this particular calibration, workers tend to accept a larger cost in terms of leisure time than the transfer they cash in. As the latter is cashed in only once a successful contact has been made, employment becomes relatively more rewarding than unemployment when compared to the benchmark economy conditions. This occurs despite the fall in the equilibrium wage. Hiring subsidies affect strongly reservation productivity. Tightness' increase does not stimulate search enough in order to compensate for the dampening effect that lower reservation productivity has on search. For large values of  $\lambda$  and  $e$  (1.2 and 0.65 respectively) some perverse effects arise. Search intensity is lowered suddenly and reservation productivity rises under the search subsidy scheme, and tightness decreases suddenly under the hiring subsidy scheme. Under the search subsidy scheme leisure becomes "too subsidized" as search cost falls dramatically. Under the hiring subsidy scheme, hiring becomes too subsidized too. Vacancies jump ahead and the fall in search intensity

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<sup>24</sup>The laissez-faire economy unemployment rate is 5.1%.

becomes sharper compared with lower level of hiring subsidy. The boosting effect on hiring makes the fall in equilibrium wage less pronounced as well, making unemployment worth higher than for lower levels of subsidy.

If we now turn to results contained in table 3, optimal values for  $\lambda$  and  $e$ , in terms of cost effectiveness, can be set respectively at 0.3 and 0.1. At this "optimum", equilibrium values are sensibly different when comparing the two instruments. Unemployment is reduced by almost 1.3% under the search subsidy scheme while it is reduced by almost 1.2% under the hiring subsidy scheme (see figure 2). Adjusted aggregate efficiency ( $gnpa$ ) is 3% ahead with search subsidies and 2.5% with hiring subsidies. If we consider non-adjusted aggregate efficiency ( $gnp$ ), improvement at optimal values of policy instruments are of same scale.

Once we do not control for cost effectiveness any more, then an important trade-off between unemployment and aggregate efficiency appears. In figure 3, crosses refer to  $\frac{u_b}{u'}$  and dots to  $\frac{gnp'}{gnp_b}$ , where prime values indicate values obtained for a given policy instrument value and  $b$  subscript values refer to benchmark values. When the two lines go up contemporarily, both unemployment and aggregate efficiency are positively affected. This is true for some small values of both search and hiring subsidies. When the two lines move in opposite directions, a trade-off between unemployment and efficiency appears. This trade-off is more pronounced in the hiring subsidy scheme<sup>25</sup>. When both lines decrease, the perverse effects mentioned above appear. This is observed for relatively large values of the policy instruments.

As for the equilibrium wage, it falls dramatically when hiring subsidies are introduced. This is due principally to the downward effect hiring subsidies have on the reservation productivity.

In this computational exercise efficiency condition (37) holds. As the contact part of the transition rate is Cobb-Douglas, elasticity value is constant. This means that under both policy schemes, results are optimal in terms of efficiency. However, both policy schemes lead to un-

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<sup>25</sup>This trade-off is even more pronounced when non-adjusted aggregate efficiency figures are considered.



deremployment, when new equilibrium values are related to benchmark ones. Underemployment is measured by the relative fall in reservation productivity which is more pronounced under the hiring subsidy scheme. Hence, subsidizing hiring tends to produce more underemployment than subsidizing search as reflected by aggregate efficiency.

In the  $(u, v)$  space, the VS curve shifts up slightly and the UV curve shifts in under both policy schemes. Under the hiring subsidy scheme, the UV curve shifts in, as the shift-out effect of reduced search intensity is more than compensated by the shift-in effect of lower reservation productivity. The VS curve's shift is less and less pronounced when search subsidies are considered, as its slope is decreasing with the level of the search subsidy (see appendix 2). As for the slope of the VS curve, when hiring subsidies are considered, it is increasing (see appendix 2). Hence, we observe that the shift up of the later curve tends to be slightly more pronounced as the level of hiring subsidy increases.

In this computational framework, reservation productivity plays a major role in the sense that the impact it has on the transition probability is larger than the impact of the two elements entering the matching function. This may be due principally to the particular form the distribution was given, namely exponential. As pointed out in the introduction, hiring subsidies can create jobs "on their own" however jobs creation is biased toward unemployment and can not be fully completed if search behavior is not positively affected. It is also obvious that search subsidies are not able to stimulate jobs creation directly. However by stimulating search and then by increasing the subsequent trade externality, firms hiring willingness is stimulated indirectly. Hence search subsidization is able to improve job creation without dampening search behavior. It is also clear that the computational search environment chosen here is particular but it gives good insights in terms of policy choice.

## 7 Conclusion

Targeted employment vouchers as defined in the Benefits Transfer Program, first elaborated by Snower<sup>26</sup>, are usually attributed two major drawbacks, namely deadweight and displacement. The former refers to the fact that some vouchers are paid to employees who would have been employed without the existence of vouchers. The latter means that either employed or unemployed workers who do not benefit from a policy scheme would be threaten in their status by unemployed workers benefiting from the policy scheme. In existing policy schemes, like the UK Workstarts scheme, long term unemployed become attractive to firms compared to short term unemployed or employed workers. In the above sections, the framework adopted did not lead to heterogenous groups of unemployed workers at equilibrium. Unemployed workers have a single common feature at steady state which is to be unemployed. Search and hiring subsidies aim at preventing long term unemployment from occurring, while BTP employment vouchers' type, at the first place, attempt to reintegrate long term unemployed workers into the active part of the labor market. Thus deadweight and displacement does not really have to be taken into account in assessing the relative performance of search and hiring subsidies.

Rather than in supplementary terms the two kinds of instruments have to be thought in complementary terms. On one hand search and hiring subsidies, considering that cost effectiveness and aggregate efficiency's gains are likely to be obtained in both schemes, are potentially good instruments to deal the lack of both search and hiring incentives brought by unemployment benefits. In our computational exercise, search subsidies are preferable in the sense that the trade-off between unemployment and aggregate efficiency and underemployment is less important than for hiring subsidies. On the other hand benefits transfers are a good way to allow long term unemployed workers to come back to work.

Previous sections have shown that search and hiring subsidies are good instruments, with a preference for search subsidies, to re-establish

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<sup>26</sup>See for example Snower [25].

search and hiring incentives and by consequence to curb unemployment. They are potentially cost effective and potentially aggregate efficiency improvers. These characteristics make them competitive tools when compared to wage subsidies which are usually assumed to be very effective in terms of employment but either very costly or requiring some very specific and complex redistributive schemes.

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## 8 appendix 1

Applying the implicit function theorem to system of equations (29) and (30) it is tedious but straightforward to obtain conditions (36) and (39) for

search subsidy and hiring subsidy respectively. The latter are sufficient conditions.

For search subsidy, as the numerator of the implicit function formula is always negative, that is its opposite is always positive, sign of  $\frac{\partial \theta}{\partial \lambda}$  relies on condition (36). Numerator's opposite is given by

$$2(1 - \beta)ch'(c)v'(1 - h(c)) + \lambda + \frac{(r + s)\theta\gamma}{p(\theta, c, \alpha_r)}$$

Moreover if condition (36) is satisfied, then from equation (30),  $\frac{\partial r}{\partial \lambda}$  is necessarily positive.

This analysis can be pursued for hiring subsidy. Now opposite's numerator is given by

$$\frac{\beta^2}{(1 - \beta)}(r + s + p(\theta, c, \alpha_r))\gamma - \frac{\beta^2}{(1 - \beta)}p(\theta, c, \alpha_r)\gamma$$

The above expression is always positive.  $\frac{\partial c}{\partial e} > 0$  is verified, if condition (39) holds. Again, it is easy to check from equation (30) that  $\frac{\partial \theta}{\partial e}$  is necessarily positive.

## 9 appendix 2

The relation between the slope of the VS curve and the value of search subsidy is given by

$$v\beta\gamma \left[ \frac{1}{u^2} + \frac{r + s}{s(1 - u)^2} \right] - \lambda \frac{s(1 - \beta)}{u^2}$$

It is straightforward to see that the above expression decreases as value of  $\lambda$  increases.

When hiring subsidy is introduced, this relation becomes

$$\frac{v\beta\gamma}{u^2} + \frac{v(r + s)\beta\gamma}{s(1 - u)^2} + e\frac{\beta s}{u^2}$$

Hence the slope is increasing with  $e$ .

## 10 appendix 3

### Computational Results

Table 2	$c$	$\theta$	$\alpha_r$	$p$	$q$
B.E	2.8184	0.5392	1.1567	0.3065	0.5684
S.S:0.1	2.9955	0.5461	1.1557	0.3199	0.5857
S.S:0.3	3.3633	0.5628	1.1469	0.3505	0.6224
S.S:0.5	4.3523	0.6269	1.1192	0.4387	0.6997
S.S:0.9	6.7273	0.8293	1.0124	0.7089	0.8548
S.S:1.2	6.0931	0.743	1.0363	0.6242	0.8401
H.S:0.1	2.6747	0.5566	1.0151	0.3466	0.6227
H.S:0.3	2.3076	0.6299	0.7516	0.4338	0.6886
H.S:0.5	1.8045	0.8021	0.5483	0.5052	0.6298
H.S:0.65	1.1516	1.0644	0.4795	0.4629	0.4349

Table 3	$u$	$v$	$wage$	$gnp$	$gnpa$	$t$
B.E	11.54	6.22	0.1310	1.1045	1.1018	0.08
S.S:0.1	11.12	6.07	0.1295	1.1383	1.1356	0.078
S.S:0.3	10.25	5.77	0.1258	1.1348	1.1319	0.079
S.S:0.5	8.36	5.24	0.1256	1.0899	1.0866	0.084
S.S:0.9	5.34	4.43	0.1118	1.0747	1.0714	0.088
S.S:1.2	6.02	4.47	0.1018	0.8942	0.8689	0.105
H.S:0.1	10.35	5.76	0.1091	1.1309	1.1291	0.0792
H.S:0.3	8.44	5.32	0.096	1.0764	1.0753	0.085
H.S:0.5	5.88	5.88	0.0858	1.0177	1.0171	0.091
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